Chapter 5: Historic Materials and Maintenance Methods

Modern-era coast defense fortifications currently within the Golden Gate National Recreation Area range from the 1870 earthen barbette East Battery, at Fort Winfield Scott, on the south side of the entrance to the San Francisco Bay, to the recently restored Nike missile installation SF-88L of the late 1950s and early 1960s, at Fort Barry, on the north (Plates 22 and 23). As one might anticipate, the challenges surrounding our understanding of the historic materials used to erect such a wide range of defense structures outpace our current knowledge. Nonetheless, much archival detail does exist. What follows is an introduction to topics of further research, many deserving of future consideration and some, perhaps, of more interest than others in the active preservation and maintenance of the batteries and their ancillary structures.

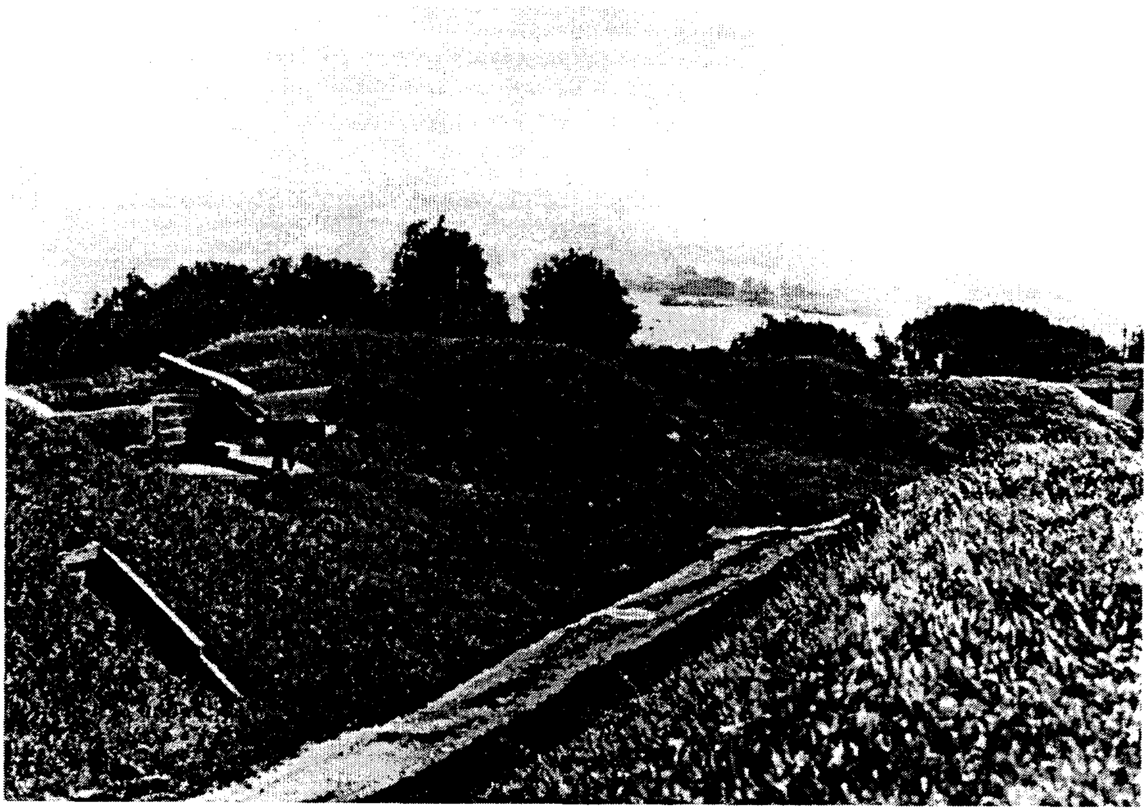

Plate 22. East Battery, Fort Winfield Scott, constructed 1872-1876. Panama Pacific International Exposition in the background to the southeast. View of circa 1914-1915. Courtesy of the Park Archives of the Golden Gate National Recreation Area.

Chronology of Structural Events: What was Built When, With What Materials?

Post-Civil War, 1865-1876

Post-Civil War construction methods and materials were characterized by a dependence on brick and stone masonry combined with enhanced earthworks. Despite the reduction of masonry fortifications such as Fort Pulaski during the Civil War, U.S Army engineers continued to rely on masonry construction through the 1870s. However, the masonry was used in support of earthworks. The brick masonry consisted of multiple wythe brick walls joined by regularly spaced header courses. The brick was set in lime-sand, cement, lime-sand mortars, or cement-sand mortars and the joints were concave or flush.

Spans were accomplished by means of segmental arches and vaulting. Wooden slab doors on metal strap hinges provided closure for bombproofs, magazines, and casemates. The guns were paired and set on terrepleins behind masonry or concrete parapets fronted by earthen berms. Emplacements were separated by masonry bombproofs covered by earth, and powder magazines were placed in central locations and reached by vaulted tunnels. The powder magazines and tunnels were also earth-covered. Earthworks were sodded to combat erosion and to blend the fortification with the adjacent landscape.

Some thought was given to the composition and slopes of the fortification's earthworks. Civil War experience with the bombardment of earthen fortifications indicated that certain slopes, densities, and compositions reacted in specific ways to both explosive ordnance and solid shot.

During the three-year period of 1868-1870, the U.S. Army Corps of Engineers initiated expansion and modernization of the coastal fortifications defending the harbor of San Francisco. Although battery construction for the harbor as a whole had begun in the early 1850s, on Alcatraz Island, the Army soon established a permanent defensive installation at Fort Point and by 1860 had plans for a large fort and permanent batteries at Lime Point to the north, and, batteries on Angel Island and at Point San Jose in the harbor and to the south. Temporary batteries followed with the Civil War, with that at Point San Jose falling into this category. Although the Army had constructed it only six years earlier, the earthen structure, with wooden platforms and magazine, was already in severe decay.

Plate 23. Nike Site SF-88L, Fort Barry. Actual view taken sometime between 1965 and 1970. Courtesy of the Park Archives of the Golden Gate National Recreation Area.

In 1868 engineers had begun the preliminary site work for the new batteries needed both north and south of the entrance to San Francisco Bay. At Fort Point, south of the harbor mouth, the Army completed a *600-foot seawall in late 1868* to protect the proposed "eastern battery" [a never-completed water battery], simultaneously undertaking experiments with the readily available "building sands" immediate to the harbor, and with Pacific Coast cements and limes. At what would be named Fort Baker (in 1897), the Army removed approximately 165,000 cubic yards of site rock through explosive blasting during 1868 and 1869, with plans for three earth-and-brick batteries at the water's edge and on the overlooking bluff. During 1870 to 1876 five batteries were under construction within the geographic parameters of this study, with substantial additional activity on Alcatraz Island: East and West Batteries to the south and Gravelly [historically, Gravelly Beach; now co-located with the Endicott-era Battery Kirby and World War II Battery Gravelly Beach], Ridge [historically two sites, Ridge and Cliff], and Cavallo Batteries, to the north. These were each open, earthen barbette batteries, requiring angled embankments for parapets, terrepleins, and traverses, and incorporating in their construction significant cubic yardage of stone, brick, and unreinforced concrete masonry for ammunition magazines, arched passageways, and gun mount foundations and platforms.[1] The Army engineered Cavallo Battery to an especially high level, considering it nearly a fortification in its own right (Plate 24).

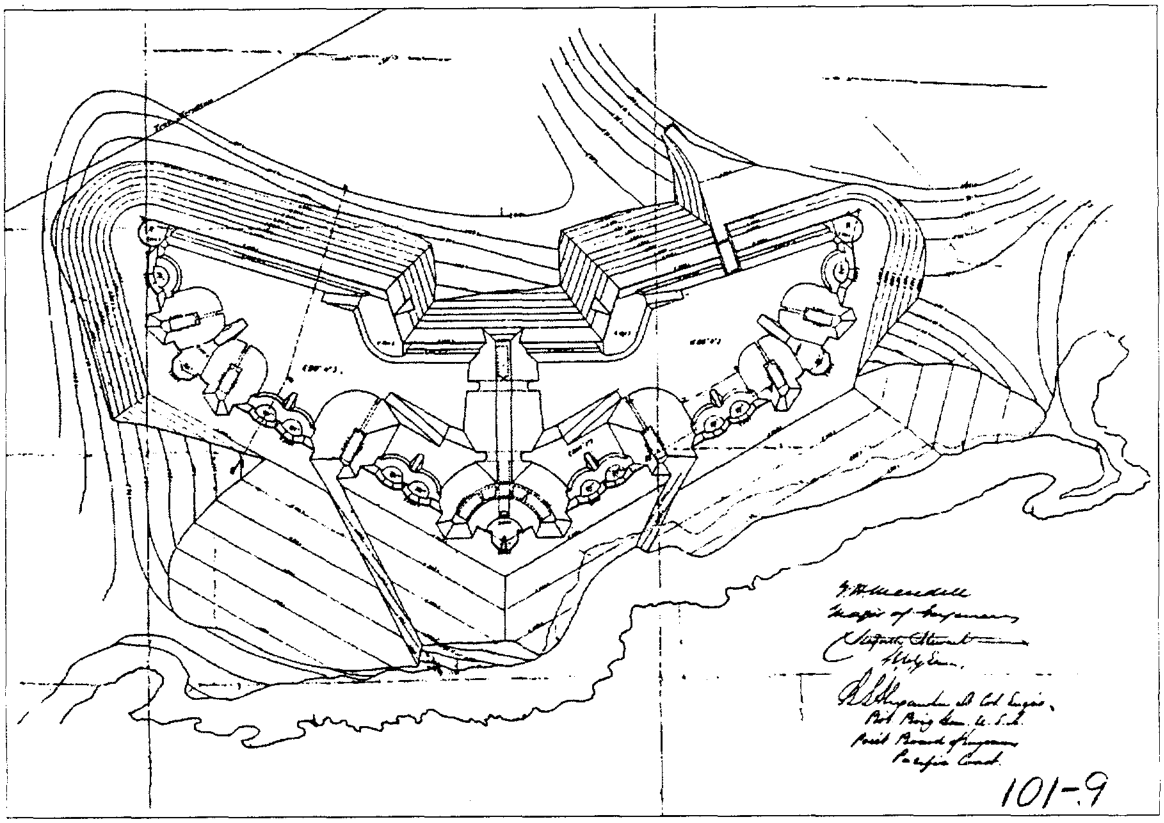

Plate 24. Cavallo Battery, Fort Baker, constructed 1872-1876. Plan of proposed works. Courtesy of the Park Archives of the Golden Gate National Recreation Area.

Foreshadowing technical challenges to come were the details of completing construction. Foundations for the gun platforms represented the heaviest construction, and were poured concrete, without reinforcing. Above the concrete foundations were the actual platforms, either of granite masonry or timber, with the latter set in the concrete. (Granite may have been the choice for mortar platforms, as was the case for the Endicott mortar battery, Howe-Wagner of 1893.)[2] As the gun platform structures were substantially heavier than the earth-and-brick works that surrounded them, they typically had settlement problems. By 1876, at least at Gravelly Battery, the Army poured additional concrete between the separating platform timbers. At Battery Cliff, the Army chose not to install the timber platforms at all—due to their known short life—and in early 1893 completely dug up the concrete foundations of the gun platforms to prepare the site for the Endicott battery Spencer.[3] Overall, woodwork employed redwood, oak, pine and sugar pine. Early mention is made of "asphaltic" and boiled oil coatings for the platforms, and lead painting of the wood doors, presumably for damp-proofing. Metal work and plate covers were noted as cast iron. And from the start, the batteries at San Francisco had a landscaping element: for the earthen batteries of the early 1870s, exterior and interior slopes were carefully sodded. Grass types mentioned in this period included barley and oats, with sodding described in "square yards" and assumed to be prepared squares (as distinct from sown seed).[4]

Endicott and Taft Periods, 1885-1916

During a long hiatus from the middle 1870s until about 1890, no battery construction went forward for San Francisco's harbor until Congress appropriated funding for the U.S. Army Corps of Engineers to act upon the recommendations of the Endicott Board. Beginning with two adjacent installations at Fort Winfield Scott, Marcus Miller and Godfrey, in 1891-1892, the years through 1904 saw construction for twenty-nine batteries which are still extant and discussed in this manual: nineteen to the south, and ten to the north. This fourteen-year period witnessed many experiments in strengthening concrete; in more effective damp-proofing through applied coatings; in revisions of site excavations and fill; and in landscaping. Limited reinforcing of the battery concrete occurred from the first.

In its infancy, concrete construction was crude and experimental. Quality was limited by inexperience in storing, mixing, placing, and finishing concrete. Construction details were developed locally based on common practice and a limited number of manuals and trade publications. Despite difficult building sites and a variety of unstable soil conditions, the San Francisco Bay Area had an abundance of beach sand and gravel and suitable stone for concrete aggregates. Water was available from local springs or reservoirs. In order to construct fortifications on selected sites, roads and logistical planning were required to transport workers, tools, materials and equipment.

By 1890, the U.S. Army Corps of Engineers had tested various concrete mixes and had a sense of proper mix proportions. The dry materials were mixed with water to produce a workable mix of a consistency that was neither too dry or too wet. Forms were of horizontal wood planks braced to withstand the weight of the mass of wet concrete. Experiments began with imbedded iron streetcar cables and rails, with aluminum-bronze hold-down bolts. Set in a circular pattern below the gun platform the reinforcing extended downwards fourteen to seventeen feet to bedrock, with alternating layers of radiating rails and coils of cable—the Army placed ten to sixteen flat rails in a spiral pattern, every two feet vertically. First such experimentation was emplacement three, Battery Godfrey, in 1895, with emplacements one and two handled in the same manner in 1896.[5] (See Plate 10, chapter 2.) Interestingly, even though the Army initiated Marcus Miller before Godfrey, work on the gun platforms was in a reversed order. The foundations for the gun platforms at Marcus Miller, however, are still recorded as more conservative in the Army annual reports, with no notation of cable-and-rail reinforcing.[6] The other sections of the batteries were not reinforced—although they were thought to be strengthened. At both Marcus Miller and Godfrey, the Army used a combination of machine-mixed and hand-mixed concrete, adding to the latter a nearly equal cubic yardage of broken concrete taken from "old magazines" (presumably from West Battery) and a small cubic yardage of rock boulders.[7]

The matter of proto-reinforcing is uncertain for the other early Endicott batteries in San Francisco, but it appears that the Army used the cable-and-rail experiment a second time at Battery Spencer on the north side of the bay, shortly after finishing the platform foundations at Godfrey.[8] For the batteries that were either in construction as of 1897, or still not fully completed, Army annual reports reference the use of steel I beams for the roof structures of the magazines—possibly as reinforcement in some cases and for ceiling trolleys. The Army introduced the use of steel I beams for battery roof reinforcement about 1895, overengineering the technique with beams from four to ten inches wide, spaced two feet apart.[9] The

Plate 25. Battery Duncan, Fort Baker, constructed 1898-1899. Pier base at rear of emplacement near entry road. Illustrates use of streetcar rails as reinforcing.

closely spaced beams were tied together with steel rods and corrugated metal pans, fitted and sprung between the bottom flanges of the I-shaped beams. Concrete was then poured over the assembled metal framework. Subsequent variations deleted the metal pans and substituted a flat formed and exposed concrete soffit between the beams. Rusting of the exposed portions of these beams caused the beams to be entirely covered in concrete so that the soffit appeared to be a continuous surface. Spencer may be the only San Francisco battery to use both iron cable-and-rail reinforcement for the foundations of its three gun platforms and steel I beams (for the ceiling trolleys of its magazines).[10] (See Plate 27, below.) Batteries that used I beams for proto-reinforcement during the 1893-1898 period included at least those of Spencer, Howe-Wagner, Saffold, Lancaster, Cranston, Boutelle, and Stotsenburg-McKinnon, and an added guardroom at emplacement one, Godfrey.[11] Isolated use of iron cable car rails does appear to have occurred elsewhere among the pre-1900 batteries, with a remnant of a pier (of unknown original purpose) still in place at Battery Duncan today (Plate 25). These first batteries continued to use cast iron for ladders, some stairs, and cranes.[12]

The evolution of concrete from unreinforced to reinforced, during the period, shows a growing understanding of the material and its characteristics. Plain concrete's primary limitation was a lack of tensil strength. This limitation was structural and affected horizontal spans, and therefore the enclosure of space. Prior to the introduction of steel into concrete, constructors had begun to understand and solve expansion and contraction problems. The use of weakened plane joints to isolate different elements in the construction and the use of surface scoring to reduce cracking was understood. Experience gained in mixing and placement of the material produced increased efficiency and better quality control. But plain concrete could not be made to span useful lengths without the benefit of arches or vaulting. For this reason, steel beams were placed so as to span between walls. The introduction of steel elements within the body of the concrete changed the material from a static compressive material to a material useful in resisting both tension and compression. In addition to experimentation with strengthening concrete construction, the Army became more sophisticated in other ways. Batteries routinely included surfacing layers of bituminous rock, three-to-six-inches thick.[13]

As of 1892, Army annual reports discuss temporary construction sites accompanying work on the batteries, with the comparisons between hand-mixing and machine-mixing the concrete. Specific recipes for battery concrete are reported, with further notations as to the physical locations of the regionally-excavated rock, gravel, and sand, and mention of the purchased Portland cement by brand name. Of interest, while work went forward on Batteries Marcus Miller and Godfrey, the Army made a change from asphaltum floors to ones of "sidewalk concrete" (alternately described as "artificial stone" and "granolithic finish."). The floors of the three emplacements at Marcus Miller were originally split: those of emplacements one and two were asphaltum, while emplacement three was sidewalk concrete. All three emplacements of Godfrey went in as sidewalk concrete.[14]

The Army plastered concrete, inside and out, with top surfaces further coated with a "bituminous paint," and with the chemical composition of both the asphaltum and bitumen paint changing as the batteries went forward. By 1897, the Army used "paraffin paint" over plastering as a maintenance technique at the batteries.[15] Another finishing technique tried as of 1896 forewent hard exterior plastering, due to the quick appearance of hairline cracking. Workers created a smooth concrete surface by using tongue-and-groove flooring boards as the final exterior formwork. They then troweled on a two-inch thick layer of concrete mixed with fine gravel and sand. The surface gravel-concrete layer replaced plasterwork, and was finished with a cement wash tinted with lampblack to dull and darken concrete's generic lightness against the landscape.[16] At Battery Duncan, set high on an isolated red-rock knoll at Fort Baker, the Army went to further extremes to blend the installation with the surrounding land form. Here the walls were visible at a distance, and were deliberately tinted red.[17] (Plate 26)

The Army also experimented with blast aprons—those features protecting a battery from its own blast effects—through variations in the extent of the aprons, their respective depths, and the physical composition. Trials with asphaltic concrete for blast aprons occurred as early as emplacement one at Marcus Miller.[18] In 1899 for Battery Kirby, at Fort Baker, the Army built the blast aprons on a composite of natural ground and fill, attempting to stabilize them by distributing "old flat iron traverse circles" throughout the concrete.[19] And, generally, a continued experimentation characterized a repetitive treatment for exposed battery surfaces—what worked best for minimal blast damage; for keeping out moisture; for achieving a reasonable weathering of settlement at the site; and, for accommodating the effects of the microclimate. As early as 1897, the Army removed the macadam from the upper ramparts (terrepleins) at Battery Godfrey, replacing them with concrete pavement. Godfrey had been finished for less than two years. The Army planned the same replacement for Marcus Miller.[20]

Site excavation for the batteries involved substantial earth moving. Dependent on the underlying soil and rock layers for stability, battery sites also demanded a variety of drains and culverts—particularly when clay was encountered. The Army prepared the site using plows and scrapers, and by blasting. Day labor removed undergrowth and trees.[21] Excavated material not reused in "strengthening" the concrete was typically placed in an immediately adjacent dump site.[22] Often the battery was backcovered with sand, in addition to earth, for greater protection from artillery fire. Planting the battery slopes continued for

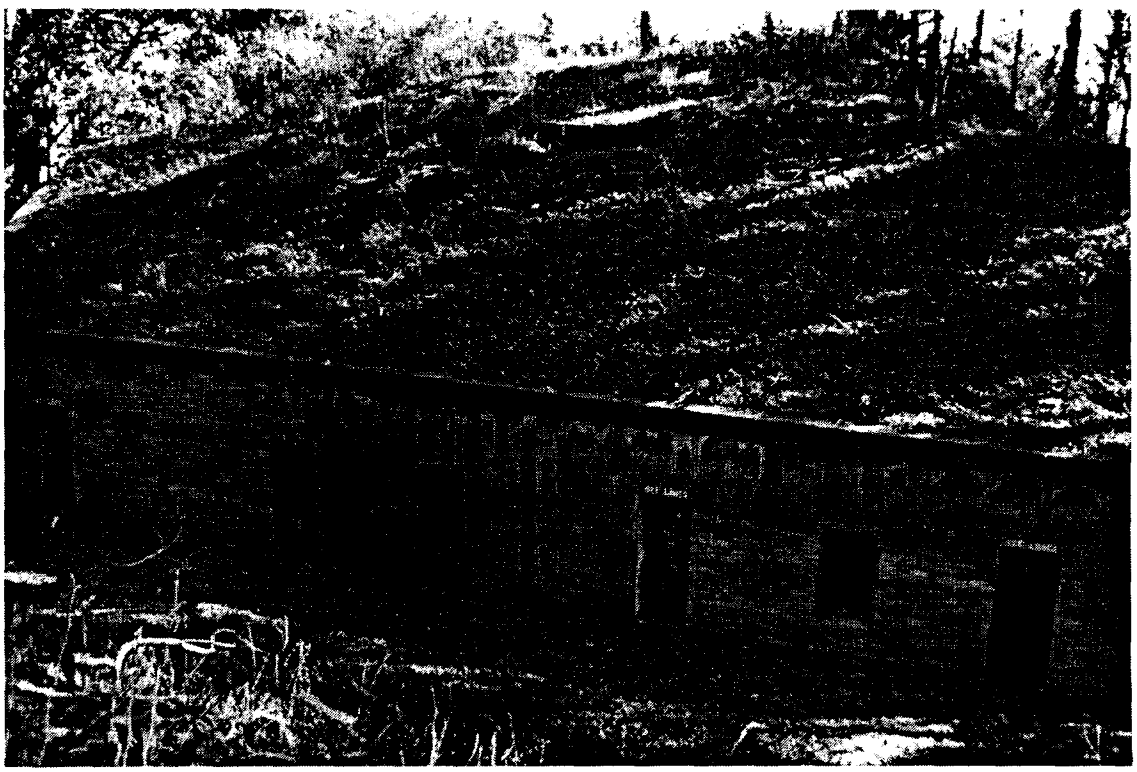

Plate 26. Battery Duncan. Rear of traverse showing fenestration, ladder to BC station, and BC station (overgrown at top of elevation).

these first Endicott defenses, sowing oats and barley into a layer of added garden loam, fertilized with manure (Plate 27).

Beginning in 1894, the Army substantially expanded its efforts at the batteries. Personnel began artificially watering battery slopes during the dry months in this year. While the Army did adopt this policy nationwide by circa 1910, using a hose attached to hydrants located at the site, San Francisco may well have been among the first locations to formalize the practice at the batteries—as a byproduct of a higher Army profile achieved due to the Midwinter Fair of January through June 1894. San Francisco's Midwinter Fair, like the Panama-Pacific International Exposition of twenty years later, was a world's fair, intended to showcase the West—with the Midwinter a directed effort by California to promote itself on the heels of the Columbian Exposition in Chicago of 1893. As of 1895, with the mortar batteries at Howe-Wagner, much more complex underlying slope work preceded grass sodding, in order to hold steeper ¾ slopes, with benching, blind drains, base retaining walls, and gutters.[23] By 1893 the first major ancillary structures associated with the batteries were in construction, with one mine casemate completed, and two nearly so. Associated roadways were formally designed, with drains and macadam surfacing.[24] At Battery Howe-Wagner, the Army built a seven-foot high redwood picket fence 1900 feet in length around the site, treating it with a dull-red lime wash .[25] A cultural landscape was unfolding.

At about the turn of the century, Army engineers had reached another set of plateaus in the use and maintenance of materials, and in detailing, for the San Francisco batteries. By 1900, experimentation in a finer quality concrete had occurred. In reorchestrating the mix of sand and gravel for the concrete, engineers developed a much harder substance, which in turn encouraged them to omit broken stone in a first trial at the small battery Orlando Wagner, Fort Baker. Use of large stone in attempts to strengthen the concrete continued, however, with a quarry opened for this purpose at a 100-foot elevation in the cliffsite at Batteries Mendell and Alexander in 1901.[26] Simultaneously the Army continued active

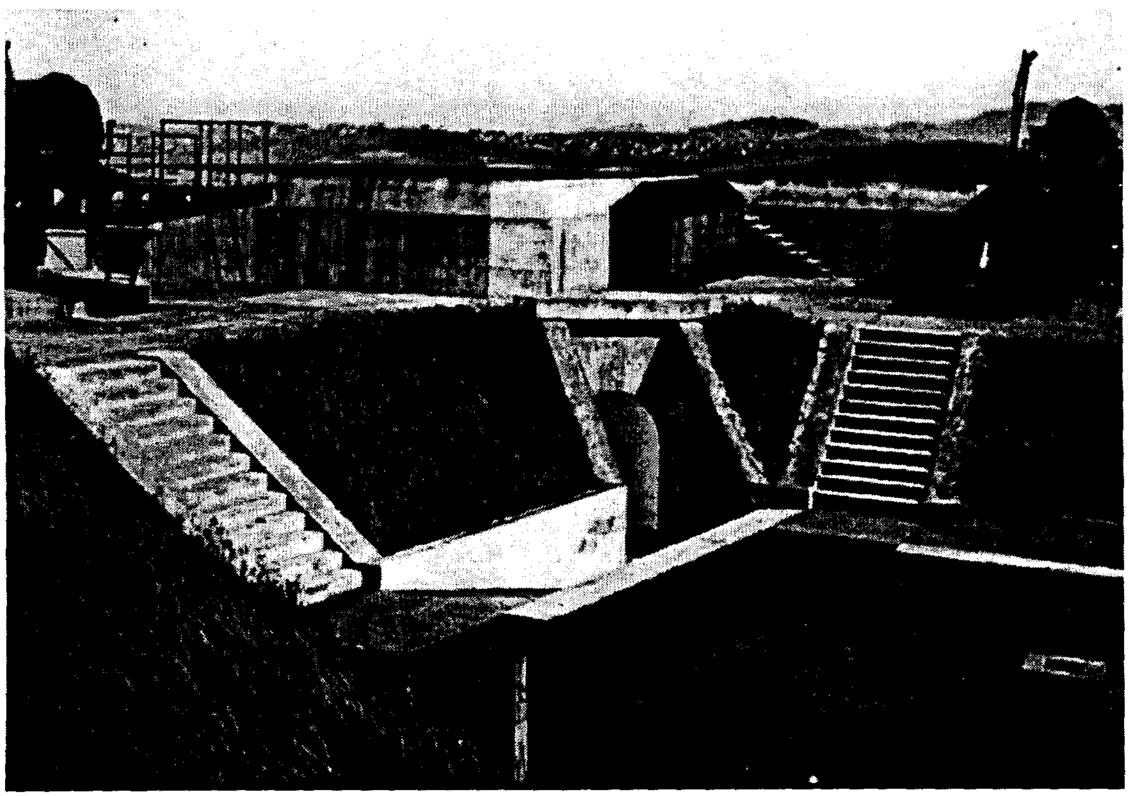

Plate 27. Battery Spencer, Fort Baker, 1893-1897. Courtesy of the Park Archives of the Golden Gate National Recreation Area.

experimentation with concrete mixes, especially with regards to the selected Portland cement. First mention was of the imported Josson & Co.'s Portland cement in 1893, and Josson's and Gillingham's in 1896.[27] In 1901, although the Army was still actively relying on two foreign Portland cements (Hemmoor's and Cannon's), it was also testing an American-made product, Red Diamond, manufactured in Utah. Red Diamond came in sacks, unlike the foreign imports which were shipped in barrels, and although of good quality, a percentage hardened in the sacks due to dampness. The Army then used these rock-like bags of cement as boulders in the subfoundation concrete work at Battery Boutelle. Foreign Portland cements were still the preferred choice, but clearly the Army was seeking widened choices through active testing of as many brands as possible. At Battery Livingston-Springer, engineers tried five brands: Scales, Josson, Cannon, Alsen, and a minor amount of Red Diamond. Of these, they used three times as much Cannon as each of the other foreign Portland cements.[28]

At the same battery, engineers demonstrated an enhanced sophistication in their understanding of, and compensation for, the planes of weakness that would inevitably manifest themselves once the concrete began to settle—due to the inherently heavier concretework of the gun platform foundations. Army *Mimeograph No.8* of 1896 had first described planes of weakness in batteries, with attempted solutions for the settlement problems. Initially efforts were focused to create as monolithic a structure as possible, and the planes of weakness manifested themselves in unwanted locations. By pouring the batteries in fully separate sections, planes of weakness were somewhat predefined.[29] In 1901, engineers in San Francisco additionally incorporated lead flashings in the construction at Battery Boutelle—to move the water away from the planes of weakness, and thus keep them from becoming a guaranteed conduit of moisture to rooms within the structure. At Battery Kirby, at this same time, leaks over the winter of 1900-1901 had forced Army engineers to re-excavate emplacement one to assess cracking from uneven settlement of the concrete. Engineers concluded that *after* settlement had fully stopped they would need to *go back* and apply lead flashings there as well.

These issues at Batteries Boutelle and Kirby make a more comprehensive point: learning at the batteries was so fluid, with overlapping and varied progress at sites under construction at the same time, that a battery started at an earlier date (Boutelle, 1898) could showcase an innovation not found in a battery begun later (Kirby, 1899), due to a later completion of the first battery (Boutelle, 1901) than that of the second (Kirby, 1900).[30] At the mortar battery Livingston-Springer, under construction simultaneously, the Army tried yet another experiment to circumvent settlement cracking and leaks. Here they weighted the battery walls with foundation offsets proportional to the expected loads, thus attempting to equalize the loads through the battery. At Livingston-Springer, engineers placed sheets of "tarred paper" between the joints of the floors and the walls, to prevent their bonding, and to create planes of weakness where they would be least likely to create unwanted leaks.[31]

At the same time, both at Orlando Wagner, Fort Baker, and just previously at the recently completed batteries on the south side of the bay, a shift occurred from wooden doors to ones made of steel sheet metal riveted to angle-iron frames.[32] Stairs at the batteries were primarily wood through 1898, with Marcus Miller somewhat unusually noted as receiving wood, cast iron, and concrete stairs in that same year, the latter for its added guard house. Although concrete stairs did appear as early as 1895 at Battery Godfrey, the Army did not incorporate them as a major design feature until 1899, at Battery Kirby.[33] The Army first mentioned adding iron handrails for the San Francisco batteries in its 1898 annual report, at Batteries Cranston, Lancaster, Marcus Miller, and Stotsenburg-McKinnon, all at Fort Winfield Scott.[34] As such, site safety must have become a concern, as handrails were added at existing batteries at about this same time.

Also in 1901, the Army began a radical experiment in its landscaping for battery slopes. Up until this year, no mention occurs of any sodding or seeding other than oats and barley, a consistency that appears to have been unbroken in San Francisco from the batteries of the early 1870s through those of 1900. In the first year of the new century, however, the Army tried alfalfa at Orlando Wagner, and a combination of oats, iceplant (*mesembryanthemum crystallinum*), bunch grass (*arundinario*), lupine, and gum (eucalyptus) trees at Livingston-Springer.[35] Since Livingston-Springer was a mortar battery, it challenged engineers through its very steep surrounding embankments. Land slides had been a significant problem for the mortar batteries from the first winter at Howe-Wagner during 1894-1895.

The experimental solution at Livingston-Springer, like solutions for other continued problems in battery construction, showed an advancing sophistication and, literally, the creation of a larger landscape. The Army planted 500 pounds of oats to cover the outer slopes of the battery, with significant labor expenditure. With this solution, the outer slopes seeded themselves very quickly and blended the grassy land form into its surroundings as observed from the sea. Army personnel made cuttings of iceplant, which was described as already "of very vigorous growth in this locality," establishing it on the inner slopes of the battery. The Army apparently did not purchase the cuttings, as the annual report showed no associated cost, but rather had men make the cuttings themselves from a site not too far distant. As the labor expenditure was only fifteen to twenty percent of that for the oats, it is assumed that the area planted was relatively small. The iceplant, also a quick grower that was drought resistant, held the steep inner slopes even more tightly than the oats, and thus protected the men and the guns from slides. The inner slopes, however, would have been an intense green with closely spaced white or pink flowering—and as such would called attention to the battery if visible to enemy ships, unless further camouflaged by a more encompassing (and dense) landscape of iceplant, or of iceplant and added low-bush, flowering, shrubs. In its inner placement, this initial planting of iceplant could not be seen. Perhaps most interesting of all, the Army planted bunch grass on all barren sandy dunes in the near vicinity of the battery. The bunch grass did two things: it prevented the sand from blowing into the mortar pits, a danger to the battery, and, it initiated a change in the larger landscape and what would come to be perceived as "the natural landscape." Complementing the bunch grass, the Army planted 100 pounds of lupine, apparently both buying seed and "gathering" it, and 4,000 eucalyptus trees immediate to the battery on the host military reservation.[36]

Efforts at Livingston-Springer in 1901 pointed to a new way of landscaping the batteries. The Army sought not just site stability, but also camouflage. Army personnel created a landscape based upon the immediate native vegetation, reorchestrating it at the batteries to include not just grasses, but also denser, low- and intermediate-height vegetation, and, trees. On the north side of the bay, during 1902, the Army used lupine and sagebrush stalks as a "brush foundation" for a 1500-foot segment of road set in deep sand between Batteries Mendell and Alexander—indicating that both the lupine and sagebrush, like the iceplant, were already actively established throughout the military reservation. At Battery Chester, also in 1902, the Army controlled the sand at the installation itself by heavily loaming the sand before seeding the slopes, and by planting the barren sand some distance from the battery to bunch grass and lupine.[37] The first couple of years of the twentieth century also witnessed heavy road building by the Army, connecting batteries. The Army typically macadamized the roads leading to the batteries, but used rock taken from site excavations for surfacing between closely spaced batteries. At Livingston-Springer red rock paved the immediate roadway at the battery.[38] At this same time, the Army also began to landscape the road banks to stabilize the sand, and likely to make them less visibly stark. At Chester, the Army bracketed both sides of the road with bunch grass.[39]

Although the Army annual report for the defenses of San Francisco harbor contains substantial information on battery construction, the information becomes more generic, with less identification of work at explicit installations, after 1902. Batteries Chester, Livingston-Springer, and Mendell are nearing completion, and Alexander, Baldwin, and Blaney are in active construction. Engineers reached the third plateau for reinforcing experimentation at the rapid-fire batteries of this group, those of Baldwin and Blaney. Heretofore the Army had specified nationwide that steel I beams were to be used for reinforcing the concrete masonry of the battery roofs, with the walls handled variously through differing concrete mixes and inclusion of large rock. Although structurally sound, the placement of steel I-beams was cumbersome, expensive, and, due to the weight of the dead load of the beams, required greater depth and more heavy concrete for coverage. The understanding that steel and concrete expanded and contracted at similar rates and the development of sophisticated mathematical calculations brought about a better integration of steel and concrete. That integration took the form of critically placed round, reinforcing rods, later modified to include twisted square bars. Placement of reinforcing bars required the construction of a metal armature (or "cage") inside the wooden forms (See Plate 28). By the time reinforcing steel bars became common, it came to be understood that the placement of large pieces of broken rock added little to the strength of the mix and were difficult to place in the confined space inside the forms. Reinforcing bars and the elimination of large rocks allowed more precision in form construction and resulted in carefully formed concrete columns, overhead slabs, and superior concrete construction. Army mimeographs officially recommended the use of twisted steel for the first time in 1902-1903, with published plans showing the size and placements for reinforcement.[40] San Francisco began employing three-fourths-inch twisted steel set at one foot centers for its rapid-fire batteries as of 1903.[41]

Endicott battery construction continued for only a few more years, through 1905 in San Francisco, with all five of the batteries from 1903-1905 likely employing twisted steel reinforcing: Chamberlin, O'Rorke, Smith-Guthrie, Yates, and Rathbone-McIndoe (Plate 28). Beginning in 1905 as well, the Army began to widen the 10-inch and 12-inch gun platforms, including those at Batteries Mendell, Kirby, Lancaster, Cranston, Marcus Miller, and Chester; this work also used the modern reinforced concrete technology.[42] This type of reinforcing was directly traceable to the patents of San Francisco engineer Ernest L. Ransome. Stanford University had used Ransome's bars in its museum of 1891, one of the earliest such major applications.[43] Just as the Endicott period closed, with a long hiatus in the erection of batteries lying ahead, numbers of steel companies and dealers offered the twisted bar as representing the "American system of concrete reinforcing." By this date, steel manufacturers added carbon to the reinforcement steel, increasing its strength (Plate 29).

With increased bearing strength and the flexibility to shape concrete elements it was possible to anchor increasingly complex gun mounts directly to concrete platforms. Precision in the placement of anchor bolts to fit gun mounts that were manufactured elsewhere was a necessity. Jigs, templates, and other mounting devices were devised to hold the anchor bolts during the placement of concrete. The placement of other inset metal items such as maneuvering rings, stair railing, handrails, hinges, and other items required setting and holding these items in place during the concrete pour. Setting inset items in concrete was a skill as new as concrete was a material. Where voids were cast into the concrete in order to receive inserts, such as handrails, molten sulfur was used as a grout.

Between 1905 and 1917, the Army built no batteries for San Francisco, with a general construction stoppage nationwide. During this dozen-year period, Army efforts were largely concentrated on making repairs, further enlarging gun platforms, and landscaping. The latter, treatment of the landscape, is of the most interest. In 1905, Army engineers reduced the steep slopes at the mortar battery Livingston, taking the slope out just over six feet and decreasing its pitch from 3:4 to 2:3. The Army replanted the inner slopes again to iceplant for one of the mortar pits, seeding the sister pit to Australian rye grass. As both pits had held iceplant in 1901, the revegetation marked a change, with a first documented appearance of rye grass.[44] In 1907 the Army noted, after inspections of batteries on the south side of the harbor, that in some cases installations still appeared as abrupt breaks in the landscape, rather than blending in. For Fort Winfield Scott, in particular, it was stated that in such a heavily forested location, trees should be encouraged to grow up and provide concealment.[45] On the north side of the bay, Cavallo Battery had become bucolic, looking agrarian in the midst of fenced horse pastures (Plate 30).

As of the spring of 1910, the Office of the Chief of Coast Artillery, in Washington, D.C., issued a memorandum taking the position that San Francisco had been approaching since 1901-1902. "Whenever coast defenses are hearafter [sic] erected, all exterior slopes of these defenses will be made to conform in aperance [sic] as posible [sic] to the surrounding ground, and geometrical contours will be carefully avoided." The memorandum directed coast defenses to plant "such trees and shrubs, as can be obtained in the neighborhood of the defenses, on the slopes of the defenses and around about them in such a way as to make them as effective a concealment of the defenses as posible [sic]... the engineer officer will

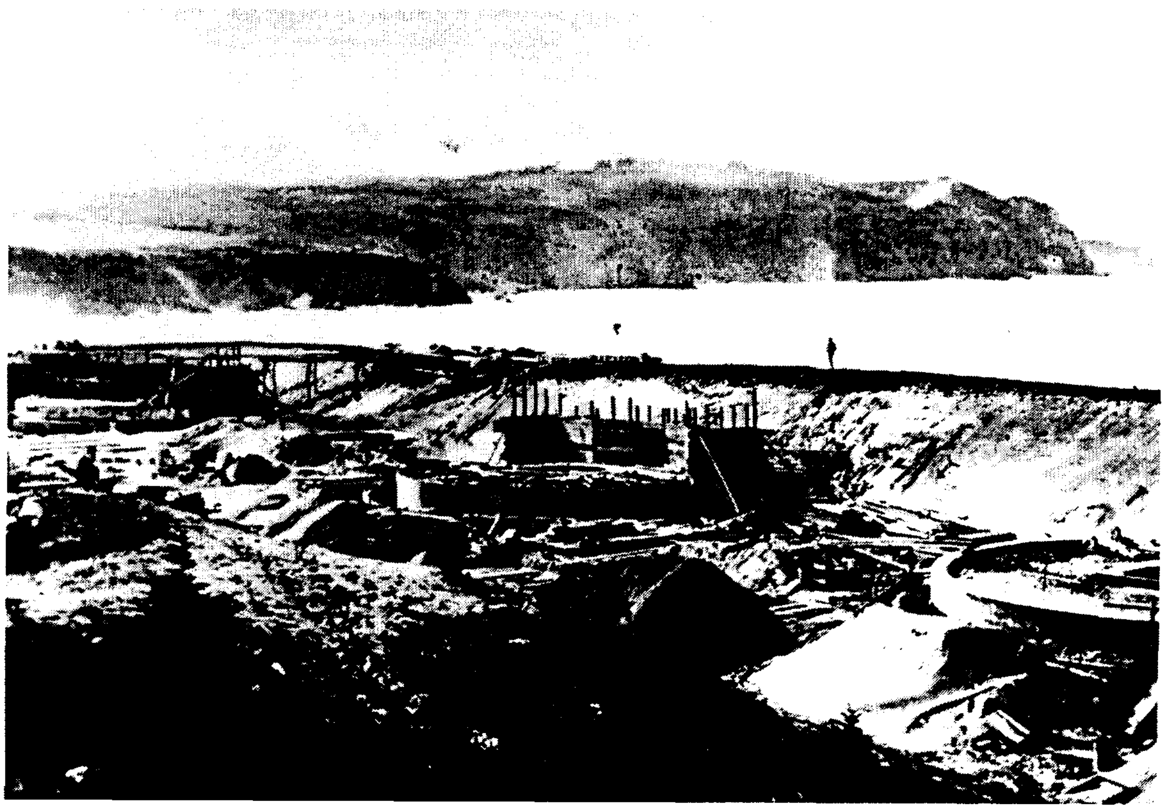

Plate 28. Battery Chamberlin, Fort Winfield Scott, 1903-1904. Under construction. Courtesy of the Park Archives of the Golden Gate National Recreation Area.

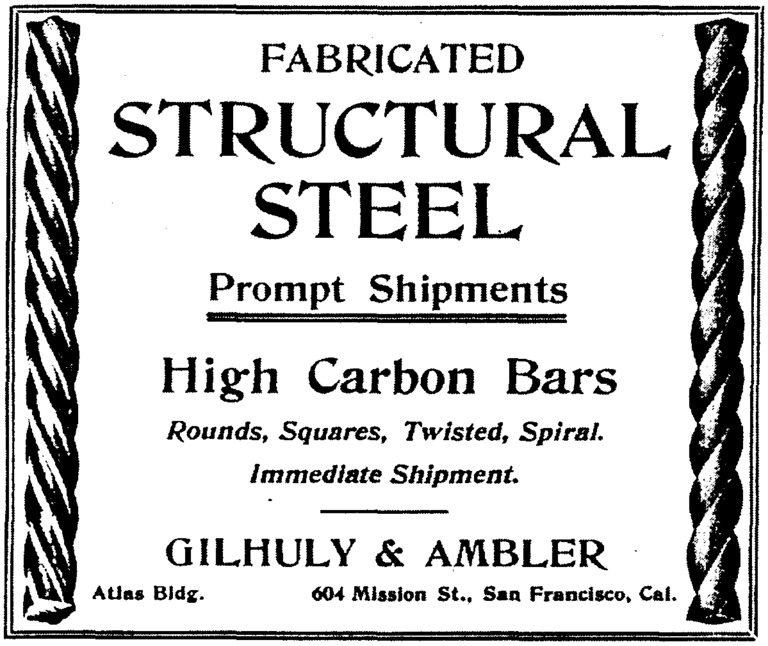

Plate 29. Advertisement for reinforcing steel in *Architect and Engineer of California*, August 1907.

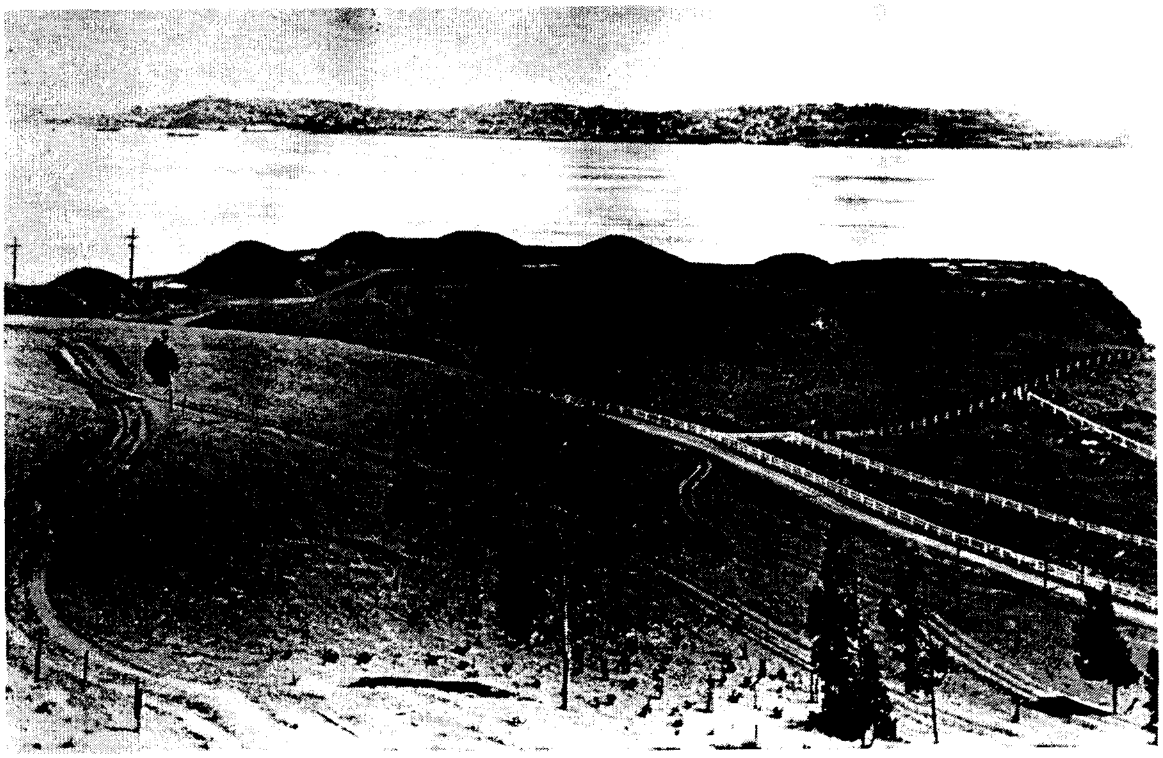

Plate 30. Batteries Cavallo (1872-1876) and Yates (1903), Fort Baker. View of about 1914. Courtesy of the Park Archives of the Golden Gate National Recreation Area.

personally see that they are properly cared for, and thet [sic] those that die are replaced when practicable [sic]." The Coast Artillery memorandum went on to describe a hierarchy of landscaping that would be most appropriate for camouflage. "Tall trees...should be planted in rear of and between adjacent batteries and in rear and on the sides of stations; low trees at the foot of batteries, bushes and shrubs on the superior slopes of batteries and low shrubs in irregular splotches between guns." The memorandum further directed that during seasonal planting, company commanders would be responsible for assigned grounds on the military reservation, where they would remove native trees and shrubs for transplanting at the batteries. A prescribed fallback position was to obtain vegetation from willing local landowners, or to find vegetation suitable to the native landscape and import it. A final point established the new formality of battery landscaping practices. The Coast Artillery asked "post commanders [to] start small nurseries at which bushes, trees, etc., may be produced and cultivated." Most compelling here, the Coast Artillery's directives are filed with the Stotsenburg-McKinnon emplacement books. Stotsenburg-McKinnon, like Livingston-Springer and Howe-Wagner before them, were mortar batteries, and demanded more sophisticated landscape and camouflage solutions due to their steeper slopes.[46]

The Army's efforts at landscaping may well have accelerated in the years immediately before the Panama Pacific International Exposition—the world's fair planned for San Francisco in 1915. The watershed year for landscape issues was 1912. At that time, after internal debate, the Army decided to "throw open all the batteries" for public visitation during the upcoming fair. It had been standing practice to fence the batteries to protect them from vandals since early in the Endicott period. Making them publicly accessible also implied an active interest in making them attractive—as the Army quite deliberately sought public goodwill and was still existing without Congressional support for new batteries.[47] The major nursery for the exposition was on the Army's grounds, established at a location in the southeastern portion of the Presidio described as "Tennessee Hollow." The directors of the exposition had appointed John McLaren, landscape architect of Golden Gate Park, as the fair's landscape engineer. Beginning in early 1912, he organized the collection of specimen plants from throughout the Bay Area, ranging from large trees to cuttings of iceplant, for propagation in an exposition nursery. After using a temporary nursery in Golden Gate Park, McLaren set up the permanent facility in Tennessee Hollow, where six greenhouses, potting sheds, a heating plant, and a lath house for small plants accommodated preparations for the exposition.[48]

The Panama Pacific International Exposition nursery at Tennessee Hollow of 1912-1914, on Army land, also notably supports the April 1910 memorandum of the Coast Artillery—to undertake such small nurseries for the propagation of native vegetation appropriate for camouflaging the batteries. And, as it was McLaren's nursery, that at Tennessee Hollow also indicates a strong likelihood that landscaping efforts on the part of the Army in San Francisco would take on the character of the California Arts and Crafts movement. Not only would native vegetation be a central feature, but chosen plants would be ones already present in the existing beach and cliff landscape near the batteries, with consideration of issues like relative natural textures, and, especially, color. Horticulture had occupied a special place in the California psyche since its shepherding by agronomist Edward James Wickson during the 1890s. Wickson, who had assumed editorship of the *Pacific Rural Press* in San Francisco during 1875, lectured at the University of California in Berkeley. In 1887 he directed all the university's agricultural lands, and in 1905 he became dean of the College of Agriculture. He published prolifically, and was well-read by the small farmer and all those who cultivated their own gardens. Wickson advocated planting flowers, shrubs, vines, and trees, most notably eucalyptus, around the California ranch house. He complemented John McLaren directly.

Wickson's books, from *The California Fruits and How to Grow Them* (1889) to *California Garden* (1915) to *California Garden Flowers* (1926), went through many editions, and he, like the Army and McLaren, talked quite a bit about appropriate landscaping.[49] Wickson described iceplant in detail, noting that "one is apt to find [it] installed here and there on the California beaches, wherever it can find a nook out of the sand-blow and the brine...and grows easily from long stem-cuttings even carelessly covered with soil, at distances of a couple of feet each way. It grows very flat...and is popular for covering rocks..."[50] For the fair, as for the batteries beginning with Stotsenburg-McKinnon in 1901, iceplant took on a concerted role. McLaren, working with San Francisco architect Hart Wood (as chief draftsman for Bliss & Faville), designed a 1150-foot iceplant double-hedge running across the grounds, eight feet in diameter and twenty feet high, with a thirty-foot tall formal Beaux-Arts arched entry (Plates 31 and 32). Using *mesembryanthemum spectabilis*, an iceplant that flowered heavily in pink, McLaren and Wood planted 8700 boxes, turning them on their sides for the much-talked about living wall.[51] The Tennessee Hollow nurseries had nurtured the iceplant cuttings, and in all likelihood, the Army's beaches had served as their source.

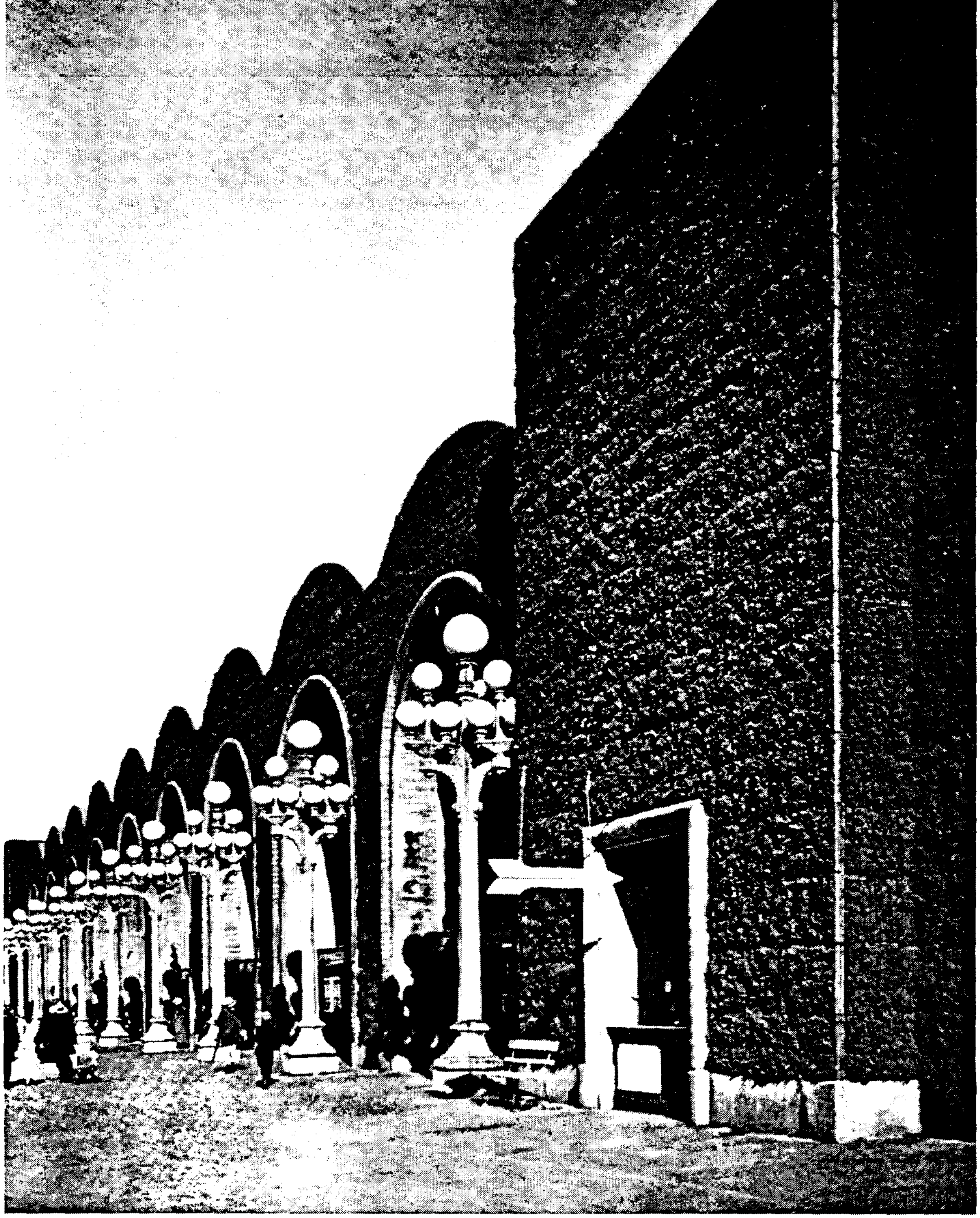

Plate 31. Hart Wood and John McLaren, iceplant wall, Panama Pacific International Exposition, San Francisco, 1915. Center arched entry thirty feet high. From *The Architect*, July 1915. Courtesy of the California State Library, Sacramento.

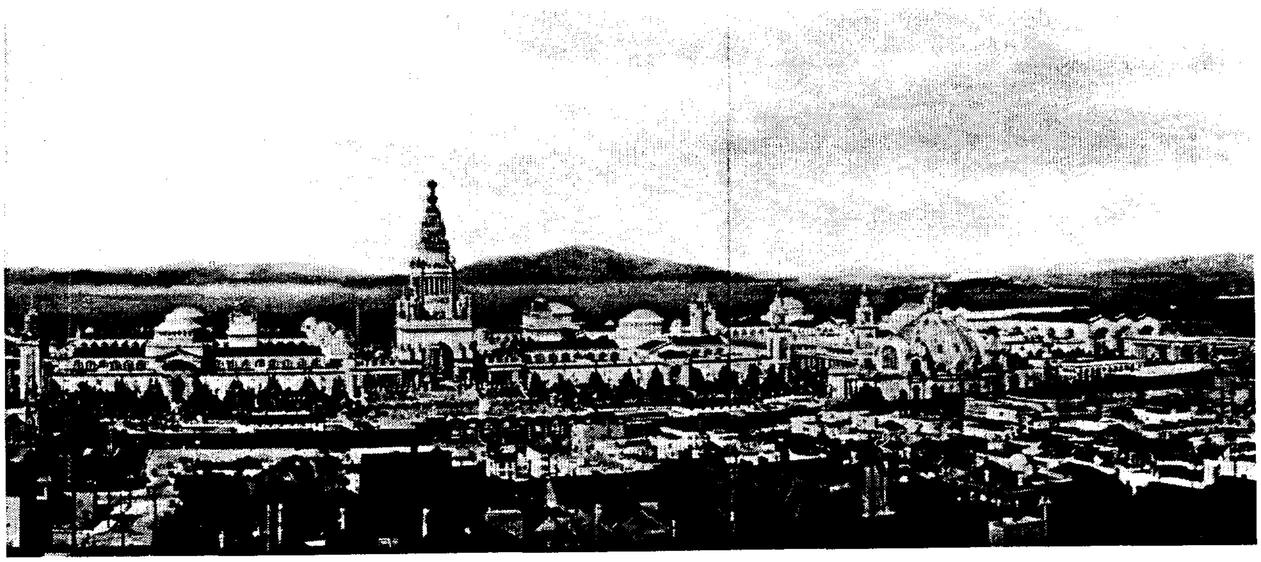

Plate 32. Wood and McLaren, 1150-foot long, living wall of flowering iceplant, Panama Pacific International Exposition, San Francisco, 1915: midground. Frank Morton Todd, *The Story of The Exposition*, 1921. Courtesy of the California State Library, Sacramento.

World War I — World War II, 1917-1945

During the final era of battery construction for San Francisco, that of World War I through World War II, achievements continued to focus on improvements in the technologies of reinforced concrete, and on experiments in landscaped camouflage. In mid-1915, the War Department convened a board to review coast defenses for San Francisco, with several new works projected. Of these, the only sizable project that was built was Battery Wallace, at Fort Barry, begun in 1917 and completed in 1921. The War Department aborted other plans. By late 1917, in fact, the Army dismounted the less-effective guns of the San Francisco coast defenses for use elsewhere during World War I—primarily the 5-inch and 8-inch guns and some of the 12-inch mortars. During this period, steel reinforcement still focused on the twisted bar, with the practice fully accepted following the rebuilding of San Francisco after the earthquake of 1906. In San Francisco, the Pacific Coast Steel Company offered "square corrugated and cold twisted, plain rounds and squares," while Woods, Huddart & Gunn advertised "twisted squares, plain squares and rounds." Predictably, as was true at the end of the Endicott period, experimental steel bar forms for reinforced concrete construction were also advocated, including Havemeyer Deformed steel bars promoted by the Southern California Iron & Steel Company.[52]

Reinforced concrete construction benefited from the development of excavation and grading equipment that made earthwork more efficient. Motorized rollers aided in the compaction of sub-foundation base materials and soil stabilization. Special rebar configurations such as stirrups, saddles, dowels, and other fittings had been standardized. Concrete mixes, free of large ungraded pieces of rock, utilized carefully graded aggregate proportions. Plywood forms were used to form large expanses of concrete surface. Chamfers, which first appeared around the turn of the century, were common devices to ease the sharp edges of the formed concrete. Improved concrete forms reduced the amount of finish work needed after forms were removed. Where weakened plane joints had been used to isolate concrete movement, expansion joints and control joints were "cast in" the larger concrete pour. Real advances, nonetheless, awaited experimentation during the 1920s and 1930s, when a highly vocal group of talented civil engineers took up the topic of reinforced concrete construction for hydroelectric projects.

These men included individuals prominent in both San Francisco-Berkeley and Los Angeles, who published their work for dam construction both in civil engineering journals and as circulating offprints. In the Bay Area, discussions by Carl Ewald Grunsky, J.B. Lippincott, Lars R. Jorgensen, John Debo Galloway, Walter LeRoy Huber, and Charles Derleth were especially noteworthy. Huber, Galloway, and

Jorgensen worked for Pacific, Gas & Electric in San Francisco. Jorgensen, a Danish engineer who had emigrated in 1901, was a particularly active discussant regarding the issues of site stability, water tightness, and appropriate amounts of steel reinforcement.[53] Army engineers appended some of Jorgensen's published discussions to their files for Battery Davis, Fort Funston, 1936-1940. The key offprint, *Solidification of Sand, Gravel and Granular Materials by Chemical Means*, addressed stabilization of a site through injecting several chemicals into "the mass to be solidified, where they react with one another to form a mortar which binds the granular material or poor rock together, forming a cemented solid mass in place." The method was intended to petrify loose ground, "rejuvenate" poor rock, and widen planned foundations—applicable not just to dams, but also to batteries.[54] It was the precursor of today's soil grouting.

With Battery Davis, the issues shifted from reinforcement of the concrete foundations and superstructure, to stabilization of the larger site. In addition to the Jorgensen offprint, the Battery Davis files included further professional engineering debate and methodology for "cement-stabilization." Army engineer Norman W. Haner, in a report of December 1938, argued that the second method, cement-stabilization, was simpler than chemical stabilization, and more reliable, and that both methods were more economical than the heretofore-used concrete spread footings.[55] Cement-stabilization created a cement-solidified backfill, on which the footings then rested. Load tests supported the hypothesis that cement-stabilized ground allowed less settlement of the heavy concrete structure than did an untreated base surface for the foundations.[56] (See Chapter 10, Sitework: Soil Stabilization.) Appended to the analysis of cement-stabilization were two articles from *Engineering News-Record*, authored by key engineers from the Portland Cement Association, and cost breakouts for its use in the construction of the Spring Street "Soil-Cement Project" in Redwood City of October 1937.[57] One article, in particular, "How to Process Soil-Cement Roads," set out the process step by step, with illustrations for each layer of the process. The Army photographed construction at Battery Davis very thoroughly, including documentary photographs of the cement-stabilization process nearly identical to those appearing in *Engineering News-Record*—from the machinery pulverizing the base soil, to the spreading of the contents of cement sacks, to the mixing of the soil and dry cement, to the spraying of water and the mechanical mixing of the soil, cement, and water, to the final compacting of the mix with "sheepsfoot rollers."[58]

Generally, with the batteries of the late 1930s and early 1940s, concrete and its reinforcing met detailed Federal specifications, as did treatments for damp-proofing. At Battery Townsley, Fort Cronkhite, for example, the cement was of Class A and Class B types, mixed per cubic yard in proportions of 5.5 bags (517 pounds) to 4.5 bags (423 pounds), with water content also called out precisely at six gallons for the Class A cement and 6.5 gallons for the Class B. Chemical composition for the Portland cement adopted standards of the Portland Cement Association, as did the sizing of the aggregates. Reinforcing steel was of Type B deformed bars, set in size and weight, and of square and round type.[59] Curing the poured concrete required fourteen continuous days keeping all surfaces wet, with the battery protected from too much sun, heavy rain, or mechanical damage.

The Army accomplished damp-proofing the foundations, and those parts of the structure in contact with replaced fill, by applying an asphalt coating to the concrete and constructing a "drainage course of split furring tile on the roof and sides," allowing water to flow away from the batteries into open-tile drains running traversely near the concrete footings.[60] Both asphalt and tile met prescribed specifications, with the tile three inches thick for the roof areas and 1.5 inches thick for the vertical walls, laid without mortar and with the split cells paralleling the slope for the roof, and, with a sand-cement mortar, the split cells running vertically for the walls. A one-foot thick layer of one-fourth inch gravel was allowed as substitution for the roof tile (Plate 33). This method of providing a damp-proof membrane for the batteries had been in place nationwide, more or less, since the publication of Colonel Eben Eveleth Winslow's *Notes on Seacoast Fortification Construction*, of 1920, with the porous layer established either as tile or broken stone. The Army had first discussed engineering of its damp-proof membranes for San Francisco coast defenses with one for Battery Mendell in 1903, noting use of "three-inch book tile." Engineers specified that the book tile be laid on a three-ply felt, tar, or asphalt coating, between it and the concrete, and that the tile be covered by a layer of fine dry sand from the neighboring hillside. For Battery Alexander, engineers used "S-shaped Spanish" tile, set in a heavy mortar on the concrete and covered with a triple layering of straw, six inches of coarse shale from nearby excavations, and sand.[61]

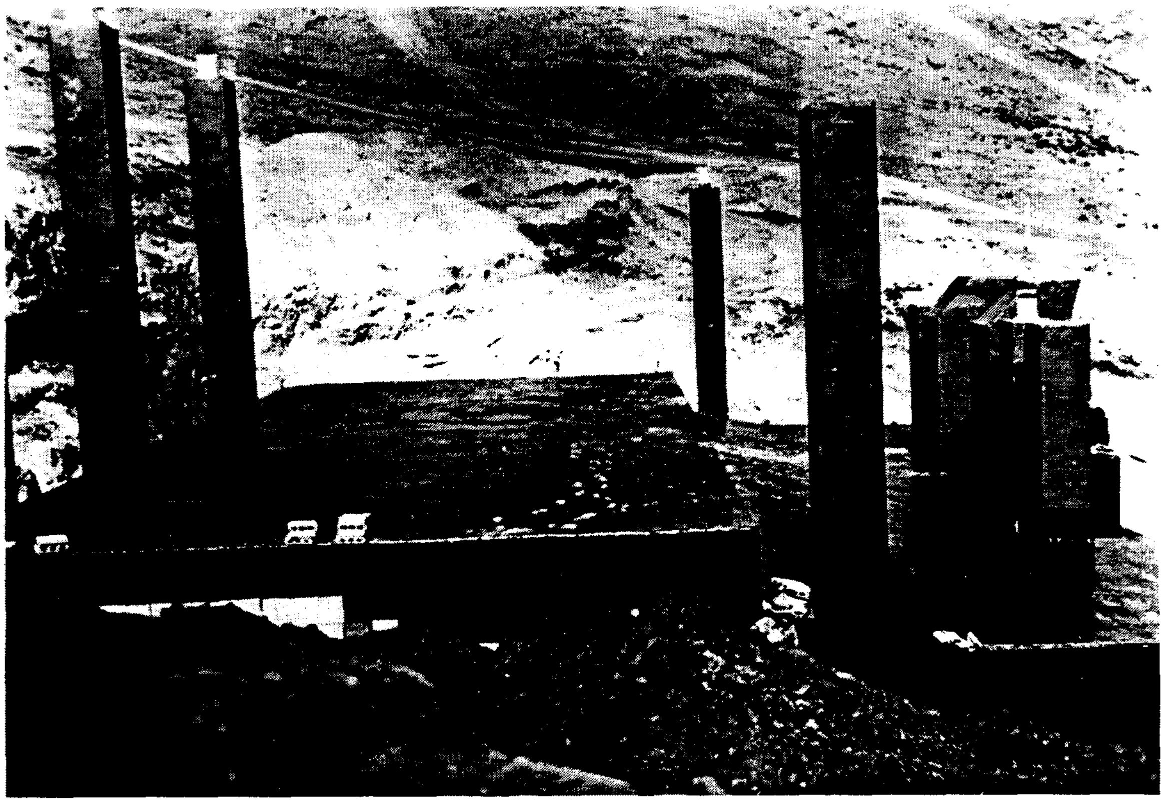

Plate 33. Battery Townsley, Fort Cronkhite, 1938-1940. Under construction, showing damp-proof membrane. Courtesy of the Park Archives of the Golden Gate National Recreation Area.

Predictably, experimentation with camouflage vegetation continued with the World War II batteries, with continued positioning on the issue of native plants. In the late 1930s, the Army completely cleared a site before beginning construction, leaving trees and shrubbery outside the immediate area. At Battery Davis—a site previously heavily planted to eucalyptus, the 1938 planting plan for the vicinity included small areas of *leptospermum*, 825 acacia trees, 1,420 pine trees, 1,070 eucalyptus trees, and selected areas of kudzu.[62] (Plate 34) The maintenance and operations plan from the same time noted that the Army collected and sowed seeds, from what it interpreted as plants typical of ("native to") the surrounding area, at the battery itself—including seeds from sagebrush, wormwood, *baccaris*, and lizard leaf. For erosion control, and to protect the sown—"native"—vegetation, the Army also planted lupine, vetch, *meliolotus indica* (all members of the pea family), and barley mustard. The intentions were to create both a temporary landscape, and a longer-term one. "The foreign plants will prevail for approximately two years and then will be crowded out by the native [typical] growth." Immediate post-construction photographs show a palm-like tree and hanging vines at the face of the battery, in addition. The Army watered landscaping carefully, with an automated sprinkler system in place, and continued planting and seeding any surviving bare spots near the battery.[63] (Plates 35 and 36) The Army also employed netting and a camouflage "mottled" paint scheme. Although not acted upon in 1910, Coast Artillery directives of that period had also suggested "the front [of the batteries] will be splashed with different colored paints."[64] As time went forward, the Army increasingly addressed camouflage not just from the land and sea, but from the air.

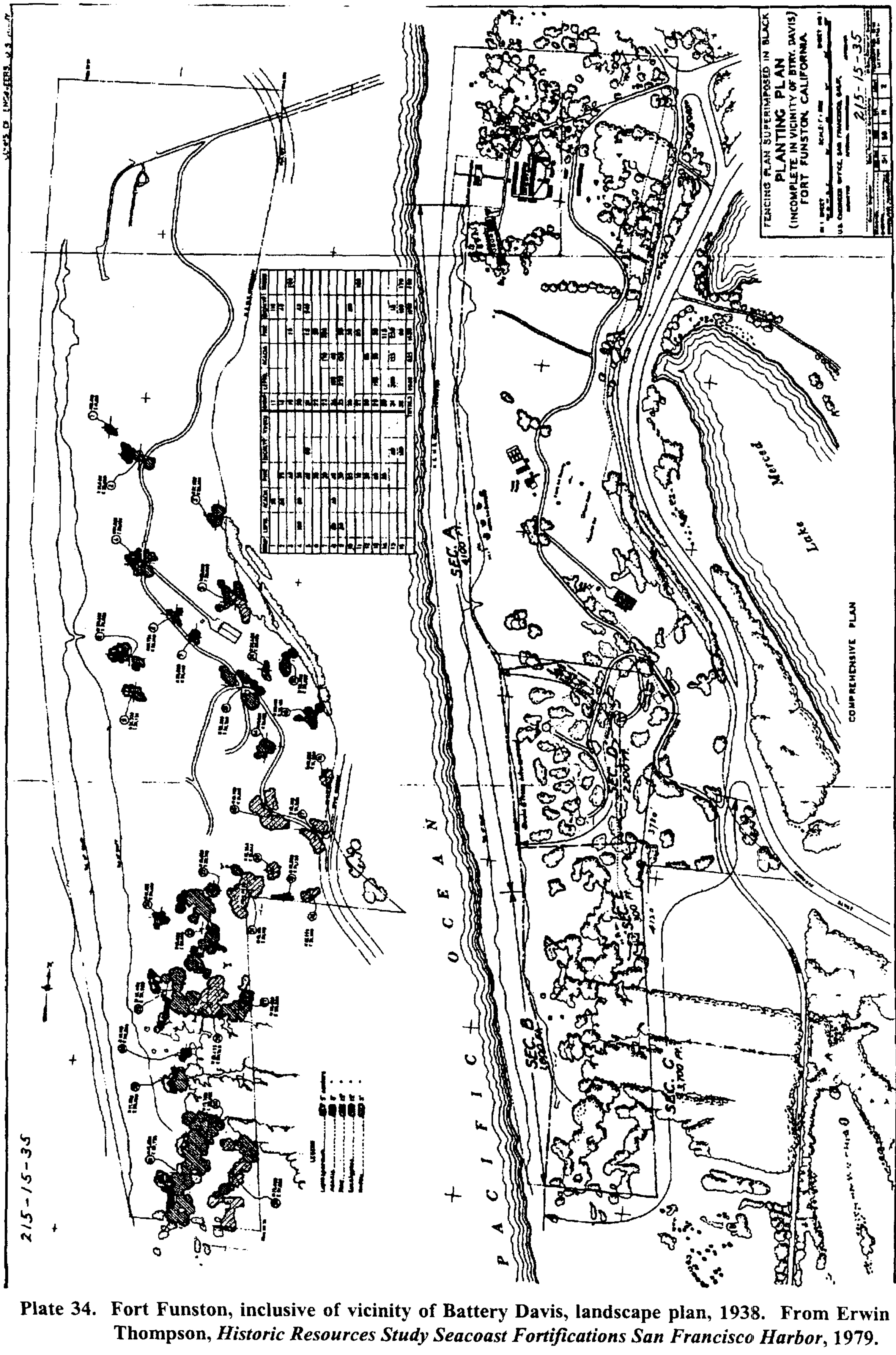

Plate 34. Fort Funston, inclusive of vicinity of Battery Davis, landscape plan, 1938. From Erwin N. Thompson, *Historic Resources Study Seacoast Fortifications San Francisco Harbor*, 1979.